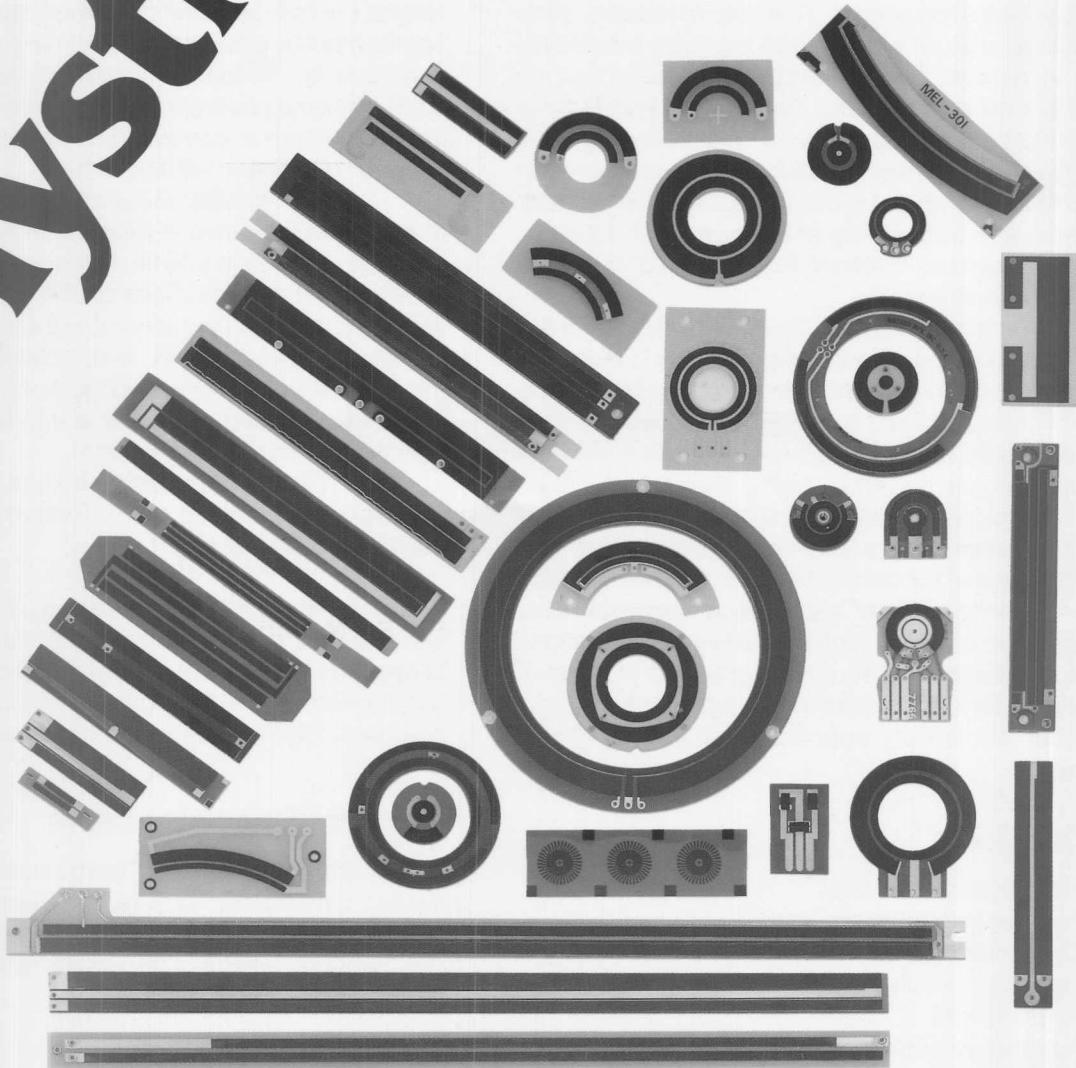


Mystr[®]



DATA INSTRUMENTS

Data Instruments Inc.

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What is MystR?

MystR® conductive plastic is a complex organic plastic compounded with various amounts of conductive materials. When cured at very high temperatures complete polymerization occurs. This polymerization, combined with precise preparation and application methods, results in a hard, smooth material characterized by durability and homogeneity. As applied, MystR films exhibit inherently high accuracies (approximately $\pm 1\%$ independent), low noise (less than .03% output smoothness), and are capable of withstanding extremely difficult duty cycles in a wide variety of environments. As such, MystR is a natural material for long-lived precision potentiometric elements.

Waters can apply the MystR material onto high-temperature substrates by means of two basic methods. MystR can be sprayed onto large sheets for later sizing and terminating of basic rectangular shaped potentiometric elements. It can also be deposited by screening to form complex patterns. Using these techniques Waters can produce custom precision potentiometric elements efficiently and economically for initial prototype requirements and subsequent high-volume production. Waters "laser correction" capabilities allow the mass production of units to high accuracy specifications ($\pm 0.1\%$ independent is routinely achieved for tens of thousands of linear elements every year) and tight tracking and/or conformity specifications for non-linear elements.

Applications

Typical applications include:

- Position transducers
- Servo controls
- Lighting controls
- Audio faders
- Automotive sensors
- Precision instrumentation
- Non-Linear systems
- Valve controls
- High temperature applications
- Plotters
- Recorders
- Medical equipment
- General feedback systems
- Gimbals/Actuators

Waters works with its customers to integrate precision elements into the space available for the application. This approach frequently allows the designer to reduce the bulk and cost of conventional potentiometric approaches by eliminating redundant shafts, bearings, and housings. The cost of complex linear motion to rotary motion linkages may also be eliminated when the basic existing motion is converted directly to a proportional linear or non-linear voltage output.

The proportional output from a MystR element may be used to drive a wide variety of systems. The simplest application is to tie the output directly to a DVM for readout of position. Careful selection of the full scale voltage applied to the element will allow the readout to directly represent inches, feet, millimeters, percent of travel, or special requirements. A more sophisticated electronic package can allow you to use the feedback signals to control the operation.

Typical examples of such a use are control of pen movement in recorders and indication of the position of a valve at a remote site.

The element itself can be operated either by the equipment itself to provide position feedback or can be an operator controlled device. MystR elements are in wide use, for example, in the audio and lighting industry where precision, high-quality faders are required.

General Specifications

For full definition of terms see "Industry Standards, Wirewound and Non-Wirewound Precision Potentiometers", published by the Variable Resistive Components Institute. (Available upon request from Waters.)

Noise

0.03% output smoothness

Resolution

Essentially infinite

Accuracy

Independent and absolute linearity to $\pm 0.025\%$

Resistance-Temperature Characteristic

Typically $\pm 5\%$ maximum change in total resistance over standard operating temperature
 $\pm 200 \text{ PPM}/^\circ\text{C}$ available in some resistances

Operating Temperature

-55°C to 125°C standard... optional to 225°C in some designs

Power Ratings

1 watt/cm²

Resistance Tolerance

±20% standard (±10% optional)

Output Functions

Linear, log, audio, or custom non-linear

Environmental

Operates under wide variety of "hostile" environments

Function Lengths

Up to 160" for linear motion and to 359° for rotary units

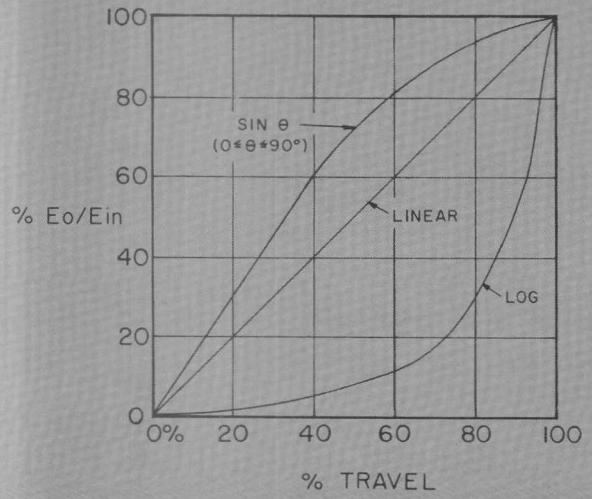
Output Functions

The most common output function is linear, with varying degrees of accuracy. Accuracy of linear functions is typically specified by the linearity of the device. MystR elements are only rarely specified at greater than ±1% independent linearity because of the inherent control we have over our process, and higher accuracy linearity is the norm. Depending upon length, our laser correction procedures allow us to tailor the elements to achieve ±0.1% independent linearities with excellent yields. Better than ±0.1% can also be achieved.

Length is important when specifying independent linearity. As a rule of thumb, the chart below summarizes what we have found to be the guidelines for practical linearity for a given function length.

Function Length	Independent Linearity
less than 1"	± 0.25%
1.0" to 3.0"	± 0.15%
3.0" or more	± 0.05%

EXAMPLES OF MONOTONIC FUNCTIONS



MystR elements can also be corrected to generate non-linear monotonic functions. Waters routinely produces elements to log and modified audio for its line of standard audio faders.

Conformity and tracking requirements for non-linear elements can also be tailored to individual specifications. Our standard log attenuators, for example, are specified to track within ±1dB over the 0 to 40dB portion range.

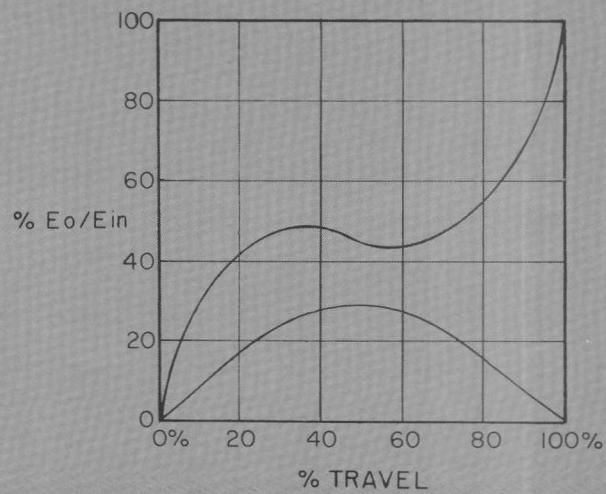
Configurations

As the front cover photograph depicts, Waters has the ability to provide a wide range of configurations. Shapes can be simple or complex. Units may have a parallel collector strip to eliminate the need for wiper pigtail leads. Termination and mounting methods vary widely.

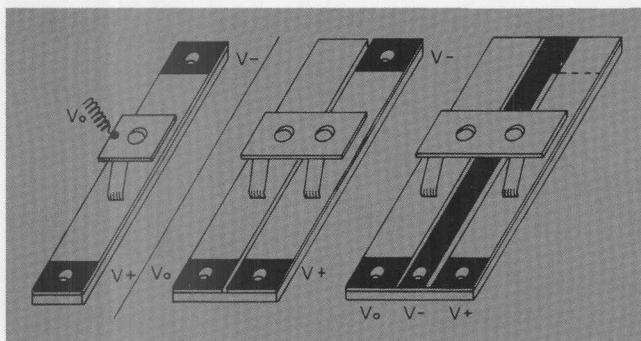
Major configuration tradeoffs to consider are as follows:

- Terminations** — Terminations are silver-loaded versions of MystR conductive plastic. Typically, terminals or eyelets are provided as solder points, or leads are attached at the factory. A wide variety of terminals, including snap-on terminals with mating female receptacles are available. All eyelets and terminals are gold-flashed to eliminate the danger of intermittent connection from oxidation of base metals. Some applications employ springs or clips that are held against the conductive terminations.
- Mounting** — The basic MystR element is first deposited onto a high temperature .005" thick substrate. This is rarely usable in this form if only for materials handling problems with so thin a film. Thus, the film is next laminated to a backing material. Typically .032" thick, epon fiberglass is used for the backing material. This can be provided with mount-

EXAMPLES OF NON-MONOTONIC FUNCTIONS



ing holes for hardware connection to your equipment or with a highly effective pressure-sensitive adhesive backing that allows the element to be directly applied to a clean surface.



- C. **Collectors** — The simplest configuration would have a resistance element only without collector. A pigtail lead off the wiper would be required. However, if a parallel collector strip is used, combined with a dual wiper to pass the pick-off voltage to the collector, then the pigtail is not needed. The parallel collector also presents the same long-lived MystR surface to the wiper as does the resistance element.
- D. **Screened Elements vs. Fabricated Elements** — If a simple resistive element with a rectangular shape is desired, only minimal tooling is required. For such units, large sheets of MystR are sprayed and cut to form individual elements. If the shape is non-rectangular (for example, disc-shaped) or high volume rectangular shape, then proprietary screening methods are used allowing the units to be manufactured in a very cost-effective manner. This process uses precision masks to form the images and a punch and die to produce the final shape.
- E. **Prototypes and Small Quantities** — Waters provides engineering assistance in the designing of prototypes using a standard element or a new custom design leading to volume production. Designs requiring a "screened" element will require some tooling even for prototype quantities. The tooling required for screened prototypes is generally applicable to subsequent moderate volume production runs.

Design Consideration

MystR films, like any conductive plastic, or any non-wirewound element, are characterized by a phenomenon known as "contact resistance variation". This can be thought of conceptually as a phantom resistor in series with the wiper. The "resistor" (R_c) varies randomly with a typical value of $\pm 2\%$ of the element's total

resistance. The effect of contact resistance variation is neither predictable nor repeatable.

If virtually no wiper current is being drawn, as in a typical non-loaded potentiometer application, then this resistor is transparent to the system. However, if you draw wiper current, then a random voltage is developed across " R_c " and this random voltage is superimposed upon the output of the pot itself. Use as a rheostat, or looking into a relatively low-impedance load, will generate wiper current. However, buffering the output in the case of a heavy load, or using a pot to drive an op-amp for a current source in the rheostat mode can effectively eliminate this phenomenon.

Life Specifications

Life expectancy of an element is a very difficult parameter to forecast responsibly because of the many factors that influence wear. MystR elements have been tested by our customers to well over one billion dither cycles and yet remained fully within all specifications after the test. Other units were fully approved for several under-the-hood automotive applications after severe testing under the most strict conditions the industry has yet seen. The type of wiper, environment, nature of mechanical cycle and linkages, and the application itself are but a few of the factors influencing life of an element. Although not called for in the majority of applications, Waters has a series of design and process options available that can further enhance life for special requirements.

Although it is impossible to make any blanket statement on life specifications, over the years, we have found that, as a starting point only, a typical 0.5% independent linearity element under "good" conditions (the typical recorder or plotter application, for example) can be expected to realize well in excess of 100,000,000 dither cycles. The specifics of the application then dictate whether we should raise or lower this rough estimate.

To insure that Waters can fully meet your requirements, contact us to suggest a MystR potentiometric solution that is practical, and to design our elements to fit **your** specifications. The process of designing and producing a custom element to your exacting specifications is far from simple, but when complete, you can count upon ten, a thousand, or several million elements that will consistently and reliably do the job **you** want, in the environment **you** face, to the specifications **you** set.



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